

**CONCORDIA UNIVERSITY**  
**DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING**  
**ELEC 442 DIGITAL SIGNAL PROCESSING**

**Fall 2008**

**Lecture Information**

Lecturer : Dr. William E. Lynch  
Lectures: Tues & Thurs. 8:45-10:00, BE-245  
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**Preface**

Digital signal processing has become an area of major significance in the past three decades. With the increasing sophistication of digital computers and special purpose hardware, a variety of powerful signal processing techniques which had previously been impractical to implement are now commonly utilized. Applications of these techniques are prevalent in such diverse areas as biomedical engineering, acoustics, sonar, radar, seismology, communications, control, image processing, and audio recording. This course is intended to provide an understanding and working knowledge of the fundamentals of digital signal processing. Its purpose is to enable you to apply digital signal processing concepts to your own field of interest, to make it possible for you to read the technical literature on digital filtering, and to provide a basis for the study of more advanced topics and applications.

**Course Objectives**

At the end of this course you should:

- Understand the difference between a digital and an analog signal.
- Understand the notion of the frequency domain for digital signals.
- Know how to determine the output of a Linear Time Invariant digital system, given its input. (In the time domain using convolution and also using the Z-transform.)
- Know how to specify a digital filter.
- Know how to design FIR and IIR filters.

**Prerequisite**

ELEC 361 Signals and Systems.

The digital systems that we will study in this class will overwhelmingly be Linear and Time-Invariant. Students should be familiar with these concepts.

Details can be found in Oppenheim and Wilsky (ELEC 361 text book). These concepts should also have been covered in ELEC 361(prerequisite for this class).

Another important concept is the frequency domain notion, or the Fourier Transform. This should have been covered in ELEC 361.

These concepts will be reviewed in class but if you feel a little shaky with them it would be a good idea to get the books and reread the relevant sections.

### **Textbook**

Oppenheim and Schafer with Buck, Discrete-Time Signal Processing. 2nd Edition, Prentice-Hall, 1999.

### **Skill – Engineering Tools**

On top of the technical content of this course you will also be practicing an important skill that all engineers must have, namely the ability to use important engineering tools. The engineering tool that you will be using in this course is MATLAB. MATLAB is a powerful tool for analysis and modeling as well as software prototyping of algorithms.

### **Homework**

One of the most important skills that you can have as an engineer is the ability to read a technical document and get something out of it. One of the best techniques to get more out of what you read is to make notes and formulate questions and hypothesis as you read. This takes the often passive activity of reading and makes it active.

Before the first class of each week you should have read the sections in the textbook for the upcoming week. You should turn in:

1. Three pages of “jottings”. This is original handwritten material concerning the material you have read. It can take any form. It might contain: summary, questions that occurred to you, insights, etc.
2. Three sentences that summarize what you’ve read.

A teaching assistant will do two things:

1. Check that you did the jottings (no photocopies!!).
2. Give you a mark on your three sentences.

We will do this for Weeks 2,3,4,7,8,9,10,11 . Using the best seven of these eight marks will yield 5% of the final grade.

### **Suggested Problems**

The suggested problems provide hands on experience with the theoretical concepts. They also are the best indicator of what you should expect on exams. There is no substitute for you sitting down and trying these on your own.

Problems will not be handed in for grades. This is to encourage you to discuss the problems with your fellow students and learn from each other, which you could not legitimately do if the assignments were for grades. Try them on your own and then if there is one you do not get, talk to a friend. The discussion you have will generally be very useful if you have both thought about and tried the problem beforehand.

A list of suggested problems is given below. Solutions to the suggested problems will appear in the photocopy location.

## **Labs**

The labs are aimed at providing hands-on experience of some of the theoretical concepts we discuss in class. The labs will be held in H-861. Right now the lab TAs have not been named. I will let you know who that is as soon as I find out. During that time the lab times the TA will be in the lab to help you. You will be assigned a new lab every two weeks. The registrar's office will already have assigned you to one of the sections. Your lab During your section's session you are guaranteed access to a computer and can kick others off if one is not available. (Better yet ask the TA to perform this unpleasant task for you.) You can also do the labs on your own time.

You should form up in pairs for the lab within your section. We will stick to the pairs rule and have no threesomes.

The labs count for 20% of your final grade. These grades are based on lab reports that you hand in after each lab. Each partner must hand in a separate lab report. I expect that while the data will be the same between two partners that the analysis is different. It should communicate that you did the experiment and that you understood the concepts. It does not need to include sections like "procedure" or "equipment". In particular you should not include material that is given in the lab handout. It should answer any questions that are asked in the lab handout, and make comments on any of the experiments that you did. Be sure to note who your lab partner was on your lab.

Your lab reports will be due two weeks after the Friday that you were supposed to do the lab. You may ask for up to one week extension beyond this due date. You do not need to give a reason, and no marks will be deducted. If you hand in a lab beyond the one week extension you will get zero. No exceptions. You can hand in labs to the lab TA (in the lab), to me (during class) or to my mailbox

## **Project**

This year we will have a project. The purpose is for you to do some extensive self-study on amore advanced topic in Signal Processing and report your results back to the class. This project does not have to be an implementation project.

### Procedure:

1. Form up in groups. Prefer groups of two. Only one or two groups of three will be approved. No group of three will have their project approved until I am sure that everyone has a partner.
2. Read a little on the topic(s) that you are interested in. Articles from the IEEE Signal processing Magazine or from the Proceedings of the IEEE are the best source.
3. Come to me with a written proposal that defines the scope of your project.  
**All projects must be approved.**
4. Do the work. I expect each person on the project to do about 20 hours (0.5 weeks) of work on the project after initial selection is done. Thus projects with three people should be more work than those with 2. Your goal is to understand your selected area and then present it so that the class can understand it.
5. You will have to hand in one report that is about 5 pages long for each partner in the group. This report should explain your selected topic in language one of your classmates could understand. Report will be due on **Thursday, November 27**. You may get a one week extension without penalty but there will be no extensions past that date.
6. In the last week of classes we will schedule about two or three sessions where each group will present their project. Each group will have 8 minutes to do their presentation. These presentations will be outside class hours. You need only attend the session where your group presents.

Marking for the project: one half for report, one half for presentation.

### Exams

There will be one midterm in addition to the final comprehensive examination. The midterm test will include the material covered in the lectures up to the exam date. There will be no make-up exams.

All exams will be closed book. However the students are permitted to bring in with them one 8.5\*11 inch sheet of paper, written on both sides. Anything may be written on this paper. Students may photocopy things and tape/glue them to their crib sheet. However the taping/gluing must be on all 4 corners so that the attachment is not a "flap" that can be lifted up and more written underneath. The surface area available is only for the one 8.5\*11inch piece of paper. Only the ENCS Faculty Calculators may be used on all exams and quizzes.

### Grading

Homework	5%
Lab	20%
Project	20%
Midterm	20%

Final Exam            35%

OR:

Homework            5%  
 Lab                    20%  
 Project                20%  
 Final Exam           55%

whichever is better.

### Course Schedule (Tentative)

Date	Topic	Suggested Problems
Week 1 (Sept 2,4) Ch. 2.0-2.5	Discrete signals and systems, Linearity. Time Invariance. Stability. Causality. Memoryless. LTI systems. Discrete convolution. Linear Constant Coefficient Difference Equations	2.21,2.1 parts (d) through (h), 2.35, 2.36, 2.22 parts (b) and (d), 2.38, 2.39,2.3
Week 2 (Sept. 9,11) Ch. 2.6-2.9	Frequency Response. Fourier Transform for discrete time signals.	2.6, 2.40, 2.41, 2.42, 2.43, 2.44 (except b,e), 2.45
Week 3 (Sept. 16, 18) Class notes Ch. 3.0-3.4	MATLAB: Discrete Fourier Transform (DFT/FFT). Filter specification. Designing filters with MATLAB. Z-Transform: Definition, properties. Properties of Region of Convergence. Inverse Z transform, from tables.	3.4, 3.5,3.11, 3.48, 3.27, 3.29, 3.32, 3.21, 3.34, 3.36, 3.8, 3.52, 3.54, 3.37, 3.39(a)
Week 4 (Sept 23,25) 4.0-4.5	Periodic Sampling. Effect of sampling in frequency domain. Nyquist sampling theorem. Discrete Time processing of continuous time signals.	
Week 5 (Sept. 30, Oct 2) Class notes	Quantization and Quantizer Design.	
Week 6 (Oct 7)	Prepare for Midterm	
Week 7 (Oct. 14, 16) Ch 4.6	Change of Sampling rate using discrete time processing.	4.2, 4.21, 4.22, 4.24, 4.5, 4.20, 4.26, 4.37, 4.38, 4.39, 4.52, 4.53
Week 8 (Oct. 21, 23) Ch 5.0-5.4	Examination of systems with rational system functions $H(z)$ . Relationship between pole-zero locations and Frequency response. Effect of one pole/zero.	5.21, 5.3, 5.11, 5.28, 5.10, 5.35, 5.39, 5.41
Week 9 (Oct 28, 30) Ch 6.0-6.5	Structures for discrete time systems. Block diagram for LCCDE. Signal flow diagrams. Direct Form I, Direct Form II. Cascade forms. Parallel forms. Transposed forms. FIR structures. Linear phase FIR structures	6.1, 6.2, 6.28, 6.3, 6.25, 6.5, 6.6, 6.29, 6.38
Week 10 (Nov 4,6) Ch 7.0-7.1	Filter Design Techniques. Filter Specifications. Design of discrete time filters from continuous time filters. Impulse invariance method. Bilinear transform. Design of Analog Butterworth filters. Properties of Chebychev and Elliptic filters.	
Week 11 (Nov 11, 13) Ch 7.3,7.4	Design of FIR filters using windowing. Properties of windows. Kaiser window method.	7.25, 7.26, 7.29, 7.46, 7.27, 7.32, 7.5, 7.35

Week 12 (Nov 18, 20) Class notes	Basics of Weiner filters.	
Week 13 (Nov 25, 27) Class notes	Least Mean Squares (LMS) algorithm.	
<b>Final Exam</b>		